# PROJECTION SCREEN AND METHOD FOR MANUFACTURING THE SAME

## BACKGROUND OF THE INVENTION

[0001] 1. Field of the Invention

[0002] The present invention relates to projection screens on which images are displayed by receiving light from a light source. In particular, the present invention relates to a reflective projection screen and a method for manufacturing the same.

[0003] 2. Description of the Related Art

[0004] Overhead projectors and slide projectors have widely been used for showing materials in meetings and the like. Also, the use of video projectors and animation film projectors is spreading to ordinary households. In these projectors, light from a light source is spatially modulated to imaging light by a light valve, and the image light is projected onto a screen through an illumination optical system, such as a lens.

[0005] Some of this type of projectors can display color images and in which a lamp for emitting white light including three primary colors, which are red (R), green (G), and blue (B), is used as the light source and a transmissive liquid crystal panel is used as the light valve. In these projectors, white light emitted from a light source is divided into red light, green light, and blue light. Each color light is converged on a predetermined light path. These beams of light are spatially modulated by the liquid crystal panel, according to an image signal. The modulated light beams are synthesized to color image light in a photosynthesis portion. The synthesized color image light is magnified through a lens to be projected onto a projection screen.

[0006] Another type of projectors capable of displaying color images has recently been developed which includes a narrow-band three primary color light source, which may be a laser oscillator for emitting narrow-band light beams of three primary colors, and a grating light valve (GLV). In this projector, each color light beam emitted from the laser oscillator is spatially modulated by the GLV, according to image signals. The modulated light beams are synthesized to color image light in a photosynthesis portion, and the synthesized color image light is magnified through a lens to be projected onto a projection screen, as in the foregoing projector.

[0007] Screens used for the projectors are classified into the transmissive type and the reflective type. In a transmissive screen, projection light is emitted from the back side of the screen and viewed from the front. In a reflective screen, projection light is emitted from the front of the screen and the reflected light is viewed from the front. In either type, it is desired to form bright, high-contrast images in order to achieve a highly visible screen.

[0008] In front projectors using such a reflective projection screen, unfortunately, the reflection of external light cannot be suppressed by, for example, using a neutral density (ND) filter, in contrast to self-luminescent displays and rear projectors. In particular, it is difficult to increase the contrast on the projection screen in a bright environment.

[0009] In order to solve the problem, a projection screen **100** having an optical thin film **112** serving as a band-pass filter, as shown in **FIG. 10**, has been proposed in Japanese Patent Application Publication No. 2002-070799. The projection screen **100** includes a screen substrate **111** serving as a light absorber and the optical thin film **112** on the screen substrate **111**. The optical thin film **112** is a dielectric multilayer laminate reflecting light in a specific wavelength band and transmitting at least visible light other than the light in the specific wavelength band. Each thickness of the layers of the dielectric laminate is set according to a simulation based on a matrix method. A light diffusion layer **113** for diffusing the light reflected from the optical thin film **112** is formed on the optical thin film **112**. The light diffusion layer **113** is formed by arranging beads, using a film including a microlens array, and other common techniques.

[0010] In this projection screen **100**, only light in a specific wavelength band of the light emitted from a projector is reflected from the optical thin film **112**. This reflected light is diffused at the light diffusion layer **113** to form an image. On the other hand, the other light, emitted from the projector, is transmitted through the optical thin film **112** to be absorbed by the screen substrate **111**. Since the optical thin film **112** serves as a band-pass filter to increase light/dark contrast, a distinct image can be displayed on the projection screen **100** even in a bright environment.

[0011] However, since the light diffusion layer **113** provides a viewing angle as small as 20°, the projection screen **100** cannot achieve satisfactory viewing characteristics.

## SUMMARY OF THE INVENTION

[0012] Accordingly, an object of the present invention is to provide a projection screen on which distinct images can be formed and which exhibits enhanced viewing characteristics, and to provide a method for manufacturing the same.

[0013] According to an aspect of the present invention, a projection screen is provided which includes a substrate and a light diffusion control portion having a plurality of convex portions or concave portions on the surface of the substrate. An optical thin film overlies the light diffusion control portion and includes convex portions or concave portions having the same shape as that of the convex or concave portions of the light diffusion control portion. The optical thin film reflects light in a specific wavelength band and transmits at least visible light other than the light in the specific wavelength band.

[0014] By providing the light diffusion control portion having the plurality of convex or concave portions on the surface of the substrate and further providing the convex or concave portions having the same shape as that of the convex or concave portions of the light diffusion control portion to the optical thin film, light rays incident on the optical thin film have predetermined incident angles. Therefore, a predetermined percentage of the light in the specific wavelength band is diffuse-reflected at angles twice the incident angles. Thus the viewing angle of the screen is increased. Consequently, distinct images can be formed regardless of projection environment, and viewing characteristics can be enhanced.

[0015] According to another aspect of the present invention, a method for manufacturing a projection screen is provided. The method includes the steps of forming a light diffusion control portion having a plurality of convex por-